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PART IX

ENVIRONMENTAL PROTECTION AGENCY

CRITERIA FOR RADIOACTIVE WASTES

Recommendations for Federal Radiation Guidance

[6560-01-M]

ENVIRONMENTAL PROTECTION AGENCY

[FRL 953-2]

CRITERIA FOR RADIOACTIVE WASTES

Invitation for Comment: Environmental Protection

AGENCY: U.S. Environmental Protection Agency.

ACTION: Recommendations for Federal radiation guidance.

SUMMARY: The Environmental Protection Agency seeks public comment on environmental protection criteria for storage and disposal of all forms of radioactive wastes. All substantive comments will be considered in forming final criteria which will be recommended to the President for approval as guidance to Federal agencies. The recommended criteria establish the basic principles which should be applied in the formulation of policies, plans, programs, and decisions involving management and disposal of radioactive waste. The recommended criteria also establish ground rules to be followed in the development of generally applicable standards for radioactive waste sources. These criteria: (a) Define radioactive wastes, indicate which types of wastes should be controlled, and give examples of where these wastes originate; (b) state the goal of radioactive waste control and define limitations on institutional and other controls over certain time periods; (c) discuss the factors to be considered in assessing risk to the general public and the general environment; (d) discuss the factors which would result in unacceptable risk for different methods of disposal; (e) require that the selection, design, and operation of a disposal site must enhance isolation of radioactive wastes; and (f) discuss the appropriateness of retrievability of waste and communication of waste disposal locations to future generations.

DATE: Comments should be received by January 15, 1979.

ADDRESS: Written comments to: Manager, Waste Environmental Standards Program (ANR-460), Office of Radiation Programs, U.S. Environmental Protection Agency, 401 M Street SW., Washington, D.C. 20460.

FOR FURTHER INFORMATION CONTACT:

Dr. Harry J. Pettengill, 703-557-8927.

SUPPLEMENTAL INFORMATION: EPA is required to recommend radiation protection guidance for Federal agencies (42 U.S.C. 2021(h)). Accordingly, the Agency is developing environmental protection criteria which would be used by all Federal agencies that have responsibilities for managing or regulating radioactive wastes. This guidance, if approved by the President, will supersede any existing guidance concerning the disposal of radioactive wastes. Federal agencies would be required to comply with this guidance in carrying out their responsibilities.

Other agencies, besides EPA, which are actively involved in radioactive waste management, are the Department of Energy (DOE) and the Nuclear Regulatory Commission (NRC). The DOE is conducting research for different control technologies to store and dispose of high-level and transuranic wastes and will operate such disposal facilities. The NRC is preparing specific regulations for licensing of storage and waste disposal facilities. EPA is developing environmental protection standards for the various types of radioactive wastes. The proposed criteria will be used by all agencies in their respective programs. The schedules of the interrelated activities of EPA and other Federal agencies are being addressed by the Interagency Nuclear Waste Management Task Force established by the President on March 15, 1978, to recommend a comprehensive Federal program for the long-term management of nuclear waste.

The Agency has received considerable assistance from the public in developing these proposed criteria through participation in two public workshops and in a public forum. The proposed criteria have also been reviewed by a working group on radioactive waste, composed of Federal agencies that would carry out the guidance once approved by the President. The basis for the proposed criteria were developed in a background report which was made available to all workshop and forum participants and others on January 16, 1978 (43 FR 2223). Copies of the report are still being provided upon request. The background report will be revised to reflect the comments received from the public forum participants and on the criteria proposed herein.

DEFINITIONS

The following terms are defined for use in this notice:

Acute (radiation exposure).—A term used in reference to a single large dose of ionizing radiation or to a series of substantial doses in a short interval of time, as differentiated from chronic exposure;

Barrier.—Any medium which stops or significantly retards the movement of emplaced radioactive materials, such as a natural geologic medium or a container or solidified waste matrix engineered by humans;

Chronic (radiation exposure).—Continuous or intermittent exposure to small amounts of ionizing radiation over a long period of time, as differentiated from acute exposure;

Diffuse (waste containing naturally-occurring radioactivity).—Waste material containing naturally-occurring radioactivity in concentrations similar to that of many natural ore bodies;

Discrete (waste containing naturally-occurring radioactivity).—Waste material containing naturally-occurring radioactivity which is substantially concentrated relative to that of the virgin natural material;

Disposal.—The placement of radioactivity waste with no intent of recovery;

General environment.—The total terrestrial, atmospheric, and aquatic environments outside sites in which any radioactive waste management activities are conducted;

Institutional control.—Activities, devices, and combinations thereof which involve the performance of functions by human beings to limit contact between the waste and humans or the environment;

Isolation.—The placement of radioactive waste so that contact between the waste and humans or the environment will be highly unlikely for a chosen period of time;

Monitoring.—Measuring the quantity and type of discharges or migration of radioactive wastes from a waste management facility, or measuring changes in physical, chemical, or biological characteristics of the site and the surrounding site area;

Retrievability.—A designed capability to recover waste from an emplaced location, within a specified time;

Risk.—A general concept encompassing both the probability and the severity of adverse effects;

Site.—Any location under institutional control which has a boundary inside which radioactive wastes are handled, stored, or disposed of;

Storage.—Retention of radioactive waste at facilities with designed provisions for recovery within a defined time;

Waste management.—The range of activities for dealing with radioactive waste, including preparation, storage, and disposal.

BACKGROUND

Our responsibility to maintain environmental quality for future generations is well recognized. As enuniciated in the National Environmental Policy Act of 1969 (NEPA), it is an important national goal to "fulfill the responsibilities of each generation as trustee of the environment for succeeding generations." In applying the above

NEPA principle, EPA notes that some radioactive waste materials are both long-lived and highly toxic. These materials may pose substantial health risks to both present and future generations. EPA believes that such materials should be properly controlled. Since no current waste management technology can be expected to be absolutely effective in isolating radioactive wastes from the biosphere (particularly over very long periods of time), decisions on radioactive waste management and control must assure that radioactive waste does not pose an unreasonable risk to human health and the environment.

Some of the issues which surfaced in EPA's deliberations about such waste control decisions were: (1) The types of materials to be categorized as radioactive wastes and subject to control; (2) the efficacy of engineered controls and natural barriers to isolate wastes; (3) the usefulness of social institutions in providing control, especially their viability over time; (4) the potential health risks of wastes (over various time intervals and with differing levels of control); (5) the unacceptability of various levels of risk; and (6) other considerations such as retrievability and communication of waste disposal sites to succeeding generations to assure continued isolation.

The Agency has developed a set of proposed criteria which address each of the above issue areas. The Agency intends to use the criteria as the basis for developing environmental standards for different radioactive waste sources. EPA will transmit the final criteria to the President for his approval and publication as Federal guidance. The promulgation of the criteria as Federal guides will foster continuity in Federal programs for the disposal of radioactive wastes. The Environmental Protection Agency has addressed the aforementioned issues in concert with other Federal and State agencies, radiation protection professionals, and the public. Thus, the proposed criteria which follow are designed to guide Federal agencies in making policy, programmatic operational, and standard setting decisions for radioactive wastes by setting forth in general terms those principles which should be applied in assuring protection of the public health.

The first criterion defines radioactive wastes, indicates which ones should be controlled, and gives source examples. The next criterion defines the fundamental goal of radioactive waste control and in that regard calls for the use of institutional and natural barriers to control wastes with long hazardous lifetimes. The third criterion states that risk is the primary basis for making radiation protection decisions for radioactive wastes and discusses what factors should be taken into account in assessing the risks to individuals and populations. The fourth, and possibly the most complex criterion, addresses the difficult subject of determining when risks from the disposal of radioactive wastes are unacceptable. The fifth recommends conditions which disposal locations should satisfy. The final criterion specifies several relevant supplemental control considerations which should be used if a net improvement in environmental protection can be achieved.

The Agency recognizes that there is substantial public debate regarding the desirability of establishing a moratorium on the production of additional nuclear wastes until such time as a National Radioactive Waste Policy has been adopted. These proposed criteria do not attempt to resolve this issue. In the Agency's view the quantity or quality of radioactive material which may be produced in the future should not be permitted to influence decisions on what levels of risk associated with such materials are regarded as acceptable or unacceptable. Curtailment of the production of certain types of radioactive waste could be determined to be an appropriate waste management control concept under the proposed criteria in certain circumstances. For example, to avoid unacceptable risk, either for current or future generations, control measures requiring extraordinary precautions for waste disposal might be judged necessary. if such control measures are feasible only for limited quantities of waste then policies to limit the total amount of wastes which are generated would be an essential element of an effective control program.

Environmental Protection Criteria

The criteria proposed herein should be used as a complete set and each should be satisfied for any radioactive waste that becomes subject to control in accordance with the first criterion. Certain exceptions are recognized and these are specifically stated. Unless circumstances are such that a given criterion can be waived because prescribed conditions for exceptions are satisfied, all criteria are to be followed for any given waste.

The following proposed criteria are under consideration for the Guidance of Federal Agencies in providing environmental and radiological protection for all forms of radioactive wastes:

PROPOSED CRITERION NO. 1

Radioactive materials should be considered radioactive wastes requiring control for environmental and public health protection if they have no designated product or resource value and: (a) Are human-produced by nuclear fission or activation, fabricated from naturally radioactive materials into discrete sources, or as a result of regulatory activities are prohibited from uncontrolled discharge to the environment; or (b) contain diffuse naturally-occurring radioactive materials that, if disposed into the biosphere, would increase exposure to humans above that which would occur normally in pathways due to the preexisting natural state of the area. Examples of radioactive waste materials that should be subject to environmental protection requirements are:

All radioactive materials associated with the operation and decommissioning of nuclear reactors for commercial, military, research, or other purposes and the supporting fuel cycles, including spent fuel if discarded, fuel reprocessing wastes, and radionuclides removed from process streams or effluents.

Artificially produced radioisotopes, including discrete radium sources, for medical, industrial, and research use and waste materials contaminated with them.

The naturally-radioactive residues of mining, milling, and processing of uranium and phosphate ores.

PROPOSED CRITERION NO. 2

The fundamental goal for controlling any type of radioactive waste should be complete isolation over its hazardous lifetime. Controls which are based on institutional functions should not be relied upon for longer than 100 years to provide such isolation; radioactive wastes with a hazardous lifetime longer than 100 years should be controlled by as many engineered and natural barriers as are necessary.

PROPOSED CRITERION NO. 3

Radiation protection requirements for radioactive wastes should be based primarily on an assessment of risk to individuals and populations; such assessments should be based on predetermined models and should examine at least the following factors:

a. The amount and concentration of radioactive waste in a location and its physical, chemical, and radiological properties;

b. The projected effectiveness of alternative methods of control;

c. The potential adverse health effects on individuals and populations for a reasonable range of future population sizes and distributions, and of uses of land, air, water, and mineral resources for 1,000 years, or any shorter period of hazard persistence;

d. Estimates of environmental effects using general parameters or of health effects based on generalized assumptions for as long as the wastes pose a hazard to humans, when such

estimates could influence the choice of a control option;

e. The probabilities of releases of radioactive materials to the general environment due to failures of natural or engineered barriers, loss of institutional controls, or intrusion; and

f. The uncertainties in the risk assessments and the models used for determining them.

PROPOSED CRITERION NO. 4

Any risks due to radioactive waste management or disposal activities should be deemed unacceptable unless it has been justified that the further reduction in risk that could be achieved by more complete isolation is impracticable on the basis of technical and social considerations; in addition, risks associated with any given method of control should be considered unacceptable if:

a. Risks to a future generation are greater than those acceptable to the current generation;

b. Probable events could result in adverse consequences greater than those of a comparable nature generally accepted by society; or

c. The probabilities of highly adverse consequences are more than a small fraction of the probabilities of high consequence events associated with productive technologies which are accepted by society.

PROPOSED CRITERION NO. 5

Locations for radioactive waste disposal should be chosen so as to avoid adverse environmental and human health impacts and, wherever practicable, to enhance isolation over time.

PROPOSED CRITERION NO. 6

Certain additional procedures and techniques should also be applied to waste disposal systems which otherwise satisfy these criteria if use of these additional procedures and techniques provide a net improvement in environmental and public health protection. Among these are:

a. Procedures or techniques designed to enhance the retrievability of the waste; and

b. Passive methods of communicating to future people the potential hazards which could result from an accidental or intentional disturbance of disposed radioactive wastes.

DISCUSSION

ISSUE NO. 1: MATERIALS CONSIDERED RADIOACTIVE WASTES

The first issue that must be resolved in formulating criteria to govern the handling of radioactive wastes is just what materials are to be considered radioactive wastes within the scope of the criteria. For a given material, this judgment has two parts: Deciding that it is a "waste", and determining whether its degree of radioactivity is great enough to require that the waste material be disposed of in a way that protects against that radioactive hazard.

The primary factor in deciding that a material is a "waste" is the material's residual value. If it has no designated remaining value as a resource or a product, the material should be considered a waste. Because these criteria are addressed to the treatment of radioactive wastes, as opposed to other radioactive materials with current or possible future uses, materials which may have such uses would not be considered wastes subject to the criteria. Depending on the circumstances, the judgment of the material's remaining value will be made by the person or organization possessing or controlling it, or by a Government agency on behalf of the society as a whole. Once a material has been designated as a waste, whether or not it should be disposed of under these criteria depends on its radiological hazard.

A view expressed in the criteria development process was that EPA should set a minimum level of radioactive content below which any material should not be considered a radioactive waste. The Agency does not believe that this would be an appropriate course, primarily because no safe level of exposure to radioactivity can be established from the available evidence. As a result, EPA and other agencies concerned with radiation protection have followed a policy of requiring exposures to be reduced as much as practicable. This approach requires consideration of the circumstances surrounding any particular exposure source, and thus, precludes the establishment of any general "de minimus" level.

It does not appear feasible to formulate a criterion generally identifying those radioactive materials or exposure levels which pose so little hazard under any circumstances that they should not be considered radioactive wastes. Therefore, EPA has formulated a criterion that cites three broad classes of materials that should be considered radioactive wastes for disposal purposes: the first class consists of those materials produced artificially, either by nuclear fission, activation, or by fabrication from naturally radioactive materials into discrete sources. These materials are easily identified and described, and directly controllable.

A second class of substances which would be considered radioactive wastes under the proposed criterion are those containing diffuse naturally occurring radioactive material. However, these materials would be subject to the criterion only if they could result in exposures greater than those which would have occurred, through any pathway, if the material had not been disturbed by human activity.

The rationale underlying this distinction is that requiring the material to be treated as radioactive waste implies that its radioactivity is the decisive characteristic of the material. Yet if failure to treat the material as radioactive waste would not increase exposures over pre-existing levels, requiring disposal of the material as a radioactive waste seems unreasonable. If such an improvement is desirable, it should be for reasons other than that the material is a waste containing some natural radioactivity.

The final class of wastes which should be considered radioactive wastes for purposes of disposal under these criteria includes any retained waste materials which are prohibited by Government regulatory action from unrestricted discharge into the general environment due to their radioactive content. While this category of substances will obviously contain many wastes covered by the two previous classes, certain materials fall into neither category. Therefore, the Agency believes the restriction on discharge to the general environment is in itself sufficient basis for requiring any such material to be disposed of in accordance with these criteria. Examples of such materials could include those removed from effluent streams at nuclear reactors or phosphate fertilizer plants.

These principles have been used to formulate the following criterion for determining which materials are radioactive wastes requiring disposal under the remaining criteria. Proposed criterion No. 1 designates broad classes of materials that should be regarded as wastes whose radioactive content requires consideration in their disposal. Usual methods for control of waste materials may be used for radioactive wastes as well if such methods provide a degree of control consistent with these criteria. Other materials or classes of materials may be added to this criterion in accordance with the principles discussed above if information discovered in the future indicates a need for doing so. Therefore, the following criterion is recommended:

PROPOSED CRITERION NO. 1

Radioactive materials should be considered radioactive wastes requiring consideration for environmental and public health protection if they have no designated product or resource value and: (a) Are human-produced by nuclear fission or activation, fabricated from naturally radioactive materials into discrete sources, or as a result of regulatory activities are prohibited from uncontrolled discharge to the environment; or (b) contain diffuse natu-

rally occurring radioactive materials that, if disposed into the biosphere, would increase exposure to humans above that which would normally occur in pathways (air, water, food) due to the pre-existing natural state of the area. Examples of radioactive waste materials that should be subject to environmental protection requirements are:

All radioactive materials associated with the operation and decommissioning of nuclear reactors for commercial, military, research, or other purposes and the supporting fuel cycles, including spent fuel if discarded, fuel reprocessing wastes, and radionuclides removed from process streams or effluents.

Artificially produced radioisotopes, including discrete radium sources, for medical, industrial, and research use, and waste materials contaminated with them.

The naturally-radioactive residues of mining, milling, and processing of uranium and phosphate ores.

ISSUE NO. 2: CONTROL OF RADIOACTIVE WASTE

The management of radioactive wastes represents potential exposure of individuals and populations and the possible contamination of the general environment. These potential impacts require definitive controls to be established. Further, because of the trustee responsibility each generation has to succeeding ones, contamination of the general environment should be avoided regardless of whether humans will actually contact the waste directly. It is important to prevent both human and environmental adverse impacts. Therefore, the fundamental goal for controlling any type of radioactive waste should be complete isolation over its hazardous lifetime.

Controls for radioactive wastes are of three general types: Engineered barriers, natural barriers, and institutional mechanisms. Engineered barriers such as containers or structures generally can be considered only as interim measures for containment, despite the fact that some structures have survived intact through the ages. Stable geologic media are an example of natural barriers. Institutional controls are those which depend on some social order to prevent humans from coming in contact with wastes, such as controlling site boundaries, guarding a structure, land use policies, recordkeeping, monitoring, etc.

It generally is accepted that long-term isolation should depend on stable natural barriers. Institutional mechanisms, which are essential in the early stages of management of any waste, are short-term processes because of practical limitations. Institutional means can be very effective in isolating radioactive wastes from humans if they can be maintained. Since society's basic structure and concern about waste may change, it is reasonable to rely on such controls for only limited periods.

The choice of a time period for relying on institutional controls is completely a matter of judgment, but is basic to a determination of when use of such controls is proper. During the developmental stages of this criteria document, it was proposed that 100 years should be the maximum time period for such controls to be depended upon with any degree of assurance. The public forum participants recommended deleting the time period because if appeared to be arbitrary; however, they left the issue unaddressed in any other form.

Because there are a number of current mechanisms for disposing of various types of wastes which are based on institutional care, the Agency believes that guidance is required to assure that institutional controls are relied upon only to the extent they are appropriate. There are numerous types of radioactive wastes of such hazard potential that they will require the adoption of stricter control methods than currently practiced and will require the development of new disposal technologies which will assure better isolation that afforded by institutional control mechanisms. For this reason, when disposal decisions are made they should recognize that institutional controls are only of limited use, and if the wastes will be hazardous longer than 100 years, other means of control will need to be found.

This means that in selecting control options for wastes whose hazards extend beyond 100 years decisions makers cannot rely on restrictions on customary uses of land and of ground or surface waters. This does not mean that institutional controls are required for 100 years, or that they must stop at that point if society can still maintain them; only that people making the initial disposal decision should not plan on their use to maintain protection beyond 100 years. The judgment that 100 years is the most appropriate time interval will be further examined throughout the public comment period.

In order to assure that these principles are achieved in controlling radioactive wastes, it is recommended that:

PROPOSED CRITERION NO. 2

The fundamental goal for controlling any type of radioactive waste should be complete isolation over its hazardous lifetime. Controls which are based on institutional functions should not be relied upon for longer than 100 years to provide such isolation; radioactive wastes with a hazardous lifetime longer than 100 years should be controlled by as many engineered and natural barriers as are necessary.

ISSUE NO. 3: RISK ASSESSMENT

Radioactive wastes pose a risk of potential exposure to people and to environmental contamination, both of which vary considerably with time. In a practical sense, risk considerations and control considerations are necessarily interrelated because each influences the other. Risks will be increased or decreased depending on the effectiveness of the control imposed, and controls to some extent will be chosen depending on the severity of the risk. Although the risks of different radioactive wastes ought to be ascertained at various levels of control, in the final analysis it is the risk a waste poses over time that primarily should determine the required controls. For this reason, risk determination is a pivotal part of any environmental and public health protection policy for radioactive wastes, and is the key consideration in deciding whether and how to store or dispose of the wastes.

Risk determinations rest on a number of factors, especially the total amount of waste material at a particular location, its persistence due to form and concentration, its potential to enter the biosphere and produce adverse effects on individuals and populations, the effectiveness of various controls, and the inherent uncertainties of many of the parameters. It is especially important that the period of time for which particular radioactive wastes remain hazardous be considered from two basic standpoints: how well the control alternatives will perform in reducing the risks over time and the probability of any containment being breached.

The factors discussed above have been generally recognized and accepted as essential to risk assessments, and there is some agreement about how to take them into account. The period over which such assessments should be performed is, however, more controversial. The main constraint on choosing a time period is the reliability of the results. Health effects estimates can be useful in making public policy decisions on radiation control; however, for many long-lived radioactive wastes, the models available are inadequate over very long intervals. Projections of population size, land use, and human factors beyond a few hundred years are suspect, but the phyisical parameters of source terms, environmental transport models, and geological conditions may be reasonably predictable for a few thousand years.

Because of the long duration of potential hazards from many of the

wastes, it is appropriate to use an extended time period for estimation of health effects. In our judgment, health effects estimates can reasonably be made for periods up to about 1,000 years. Such a time period would provide consideration of both acute exposure risks and chronic exposure risks represented in many types of wastes containing both short- and long-lived fission products. A shorter time period, though less subject to speculation, may have the result of focusing control only on short-term risks that will soon disappear, when it would be equally appropriate to control the risks of long-lived components of the waste.

Some materials decay rapidly enough that virtually all their radioactivity is gone long before 1,000 years, in which case the estimation process is considerably more simple. On the other hand, some very significant waste materials persist well beyond 1,000 years, so it is important to account for this potential risk in deciding a form of control. In this case, it is desirable to have some means of comparing the potential impact on public health and the environment in order to choose the best control alternative. This can be done by physical parameters related to risk potential such as the quantity of various radionuclides entering environmental exposure pathways, their physical distribution, or the doses they may produce. Such comparisons can also be made with health effects estimates based on very general assumptions beyond 1,000 years. Although health effects estimates are desirable for these very long time periods, reasonable comparison of control alternatives can be made by other parameters such as curies released, calculated doses to assumed individuals, etc.

Impact assessments and the time periods for which they should be performed were discussed in developing the criteria. The public forum participants generally agreed that there is a need for risk assessments and that assessments should include, at least, those basic elements presented in the background report (43 FR 2223). However, the participants expressed considerable confusion about the meaning of the relationship between time and risk assessment, and recommended deletion of the time periods presented. Although the time periods chosen are based on judgment, the Agency believes it essential that meaningful estimates be made for the periods over which wastes represent potential hazards. In order to assess risks properly, it is recommended:

PROPOSED CRITERION NO. 3

Radiation protection requirements for radioactive wastes should be based primarily on an assessment of risk to individuals and populations; such assessments should be based on predetermined models and should examine at least the following factors:

a. The amount and concentration of radioactive waste in a location and its physical, chemical, and radiological properties;

b. The projected effectiveness of alternative methods of controls;

c. The potential adverse health effects on individuals and populations for a reasonable range of future population sizes and distributions, and of uses of land, air, water, and mineral resources for 1,000 years, or any shorter period of hazard persistence;

d. Estimates of environmental effects using general parameters or of health effects based on generalized assumptions for as long as the wastes pose a hazard to humans, when such estimates could influence the choice of controls;

e. The probabilities of releases of radioactive materials to the general environment due to failures of natural or engineered barriers, loss of institutional controls, or intrusion; and

f. The uncertainties in the risk assessments and the models used for determining them.

ISSUE NO. 4: UNACCEPTABILITY OF RISK

The term risk expresses a general concept encompassing both the probability of occurrence of adverse effects and their severity. Both aspects are basic to decisions on the adequacy of controls for radioactive waste. The most restrictive regulatory position to adopt would be to allow no additional risks whatever. No matter how desirable "zero risk" might be as a goal, it may not be technically or economically feasible. Moreover, society may have to forego some easily justified and beneficial activities to attain zero risk. Guidelines are required, therefore, for determining levels of risk other than zero that may be permitted. A difficulty in formulating such guidelines is that there is no generally accepted methodolgy for determining the risk that society would accept in a given set of circumstances.

Examination of risks for waste disposal systems in terms of the consequences of exposure and their probability of occurrence will result in values greater than zero which vary with the types of waste, the controls available, and the kinds and severity of events that can be postulated to disrupt isolation. Consequences may range over chronic and acute exposures of a few individuals or large groups, with probabilities ranging from very remote to near certainty over the long term for some waste types and controls.

All societies experience risks and have developed patterns of acceptance of various types of risks. For high-technology societies these patterns are difficult to discern, and they often change in relatively short time frames because such societies are continually creating new sources of risks. Thus, in the absence of established methodologies for determining acceptable risk, the Agency believes it is reasonable to state (in terms of consequence of exposure and probability of occurrence) certain unacceptable risks resulting from the disposal of radioactive wastes.

The apparent opinion regarding radioactive waste in the United States is that any risks resulting from the disposal of radioactive wastes now or in the future would not be acceptable unless more complete isolation were unreasonable. To be responsive to this public attitude, reasonable controls that are available and economically feasible should be applied. Also, because of the responsibility each generation has to succeeding ones, a key social consideration is that at a minimum the current generation should not pose larger risks to a future generation than it would be willing to accept for itself. This does not mean that the risk has to be the same in future generations, only that it would not be unacceptable to the current generation if imposed on it—even though the projected impact on the first few generations may be well below levels determined to be acceptable. Risk levels unacceptable to the current generation for a given set of circumstances would be generally precluded in formulating protection standards for the waste materials in question.

In general, risks are more readily acceptable to society if the consequences are common ones that are not highly dreaded, and are well understood situations which can be related to other common risks. On the other hand, generally beneficial circumstances which have high potential for harm appear to be acceptable to people if occurrence of the harm is virtually impossible; that is, the probability is very low. These interrelationships between probability of occurrence and consequence are not linear functions, and thus an unacceptable risk value cannot be chosen as a product of the two. Instead, one is compelled to state separately conditions of unacceptability for the consequence of quite likely adverse events, and for the probability of very harmful situations. Since a broad range of circumstances is possible for wastes, each of which has its own probability and consequence, one is dealing with a continuum of probability/consequence; thus, it is only possible to give general guidelines for

deciding when various degrees of risk would be unacceptable. These are rooted in the basic concepts discussed above: Events likely to occur will be acceptable only if adverse consequences are low and are of a common type; events with high adverse consequence potential must be virtually certain not to occur.

In order to apply these principles, as stated in the proposed criterion, the following steps are required: First, the probabilities and consequences of possible events should be determined for different types and levels of control, and secondly, the results compared to other socially determined values for similar circumstances, if possible. The following paragraphs illustrate the second step.

High consequence events resulting from waste disposal can be compared to those associated with productive, shorter term technologies such as dams, dikes, and large stores of toxic or explosive chemicals. It is well recognized that productivity is associated with the creation of radioactive wastes. However, once wastes are created there is no further productivity directly associated with them. It is also important to note that the hazards many radioactive wastes pose are often much longer-lived than the explicitly productive aspects of other technologies. For radioactive wastes which pose long-term hazards, it seems reasonable that high consequence events should be considered unacceptable unless their probability is only a small fraction of that deemed acceptable for shorter term productive technologies.

Exposure situations which are likely to occur for certain kinds of wastes would be unacceptable, under the proposed criterion, unless predicted effects would be of questionable significance, even on a statistical basis. This means that if acute exposure is projected as a likely result of waste disposal, it should affect no more than a very few individuals randomly. If large groups are likely to be chronically exposed, the projected risks should be small and no greater than comparable risks that society has already willingly accepted.

Each Federal agency that is involved in establishing policy for radioactive waste disposal will be responsible for estimating the consequences of likely radiation exposure circumstances for wastes, and for determining whether they are unacceptable based on an examination of their consistency with other established social values that have evolved for comparable circumstances. Therefore, it is recommended that:

PROPOSED CRITERION NO. 4

Any risks due to radioactive waste management or disposal activities should be deemed unacceptable unless it has been justified that the further reduction in risk that could be achieved by more complete isolation is impracticable on the basis of technical and social considerations; in addition risks associated with any given method of control should be considered unacceptable if:

a. Risks to a future generation are greater than those acceptable to the current generation;

b. Probable events could result in adverse consequences greater than those of a comparable nature generally accepted by society; or

c. The probabilities of highly adverse consequences are more than a small fraction of the probabilities of high consequence events associated with productive technologies which are accepted by society.

ISSUE NO. 5 LOCATION AND WASTE ISOLATION

It is generally accepted that long-term isolation of radioactive wastes should depend on stable natural barriers to assure isolation from the biosphere over the period that a radiological hazard persists. Obviously, the site's effectiveness in attaining this goal is influenced by its location. Therefore, it is desirable to select sites if they are reasonably available where the action of natural forces over time such as erosion, sedimentation, and crystallization can be projected to improve, rather than reduce, isolation of the wastes over the time they may represent a potential hazard if they were to enter the biosphere. Similarly, if geological media are used, they should reduce the effect of potential interaction with water to the greatest extent possible. Therefore, it is recommended that:

PROPOSED CRITERIA NO. 5

Locations for radioactive waste disposal should be chosen so as to avoid adverse environmental and human health impacts and, whenever practicable, to enhance isolation over time.

ISSUE NO. 6 SUPPLEMENTARY PROTECTION GOALS

A number of other subjects pertinent to protection of the public from radioactive wastes were discussed in the development of the criteria. Among these, most attention centered on monitoring, provision of retrievability, and passive communication of the nature of the possible hazard to future generations. In general, it was determined that, while each has positive aspects for control of radiological hazards, their application might undermine the goal of providing permanent isolation for wastes. It is difficult to maintain retrievability or conduct a monitoring program without compromising the ability to provide isolation. Furthermore, in many disposal situations which will satisfy the five criteria discussed above, the residual risk will mainly be attributable to potential failure mechanisms involving eventual intrusion by humans. Passive methods of communicating the hazard, such as markers which call attention to the waste, may sometimes be judged to provide a net reduction of risk. Other passive methods, such as creating records describing the waste, or setting aside of the land title to the disposal site, have value in reducing the likelihood of intrusion for some limited time.

An example of a circumstance where land title transfer is reasonable is a current site that has been in use for some time where optimal environmental isolation is no longer a practicable alternative, such as an abandoned mill tailings site, a nuclear test facility site, etc. In these cases, Federal ownership of the land beyond the normal period of institutional control would be reasonable to minimize potential intrusion. Such decisions should be made on a case-by-case basis and provision for specifically treating such exceptions should be addressed in standards and regulations which are promulgated for these types of wastes.

It is not appropriate to depend upon methods such as these or other similar ones for long-term control; nonetheless, when such methods would enhance overall protection from wastes, it is prudent to use them. This is particularly the case for retrievability and passive communication. Monitoring was judged by the Public Forum participants to be generally a part of early institutional controls prior to completion of disposal, and thus it is not included in the following criterion for supplementary controls. Therefore, it is recommended:

PROPOSED CRITERION NO. 6

Certain additional procedures and techniques should also be applied to waste disposal systems which otherwise satisfy these criteria if use of these additional procedures and techniques would provide a net improvement in environmental and public health protection. Among these are:

a. procedures or techniques designed to enhance the retrievability of the waste, and

b. passive methods of communicating to future people the potential hazards which could result from an accidental or intentional disturbance of disposed radioactive wastes.

IMPLEMENTATION AND FOLLOW-UP

It is expected that Federal agencies would use these criteria as a basis for developing detailed standards for radioactive wastes which are consistent with its particular requirements. The Agency, in cooperation with other Federal agencies, will follow the implementation of these recommendations, and will promote the coordination necessary to achieve an effective Federal waste management program. Periodically, the Agency will interpret and expand upon each of the recommendations as required to assure effective implementation by Federal agencies in accordance with new and changing information.

DOUGLAS M. COSTLE,
Administrator.

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